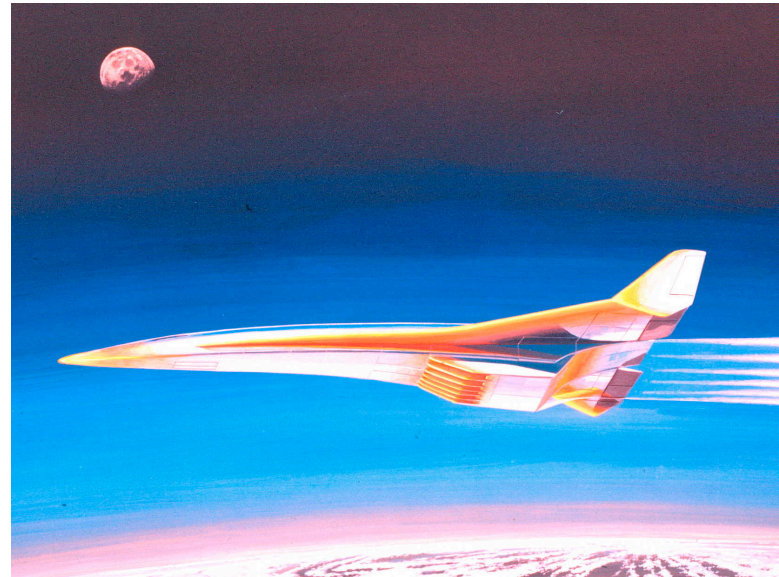


Federal Investment and Aerospace R&D



Roger D. Launius
Division of Space History
National Air and Space Museum

June 10, 2003

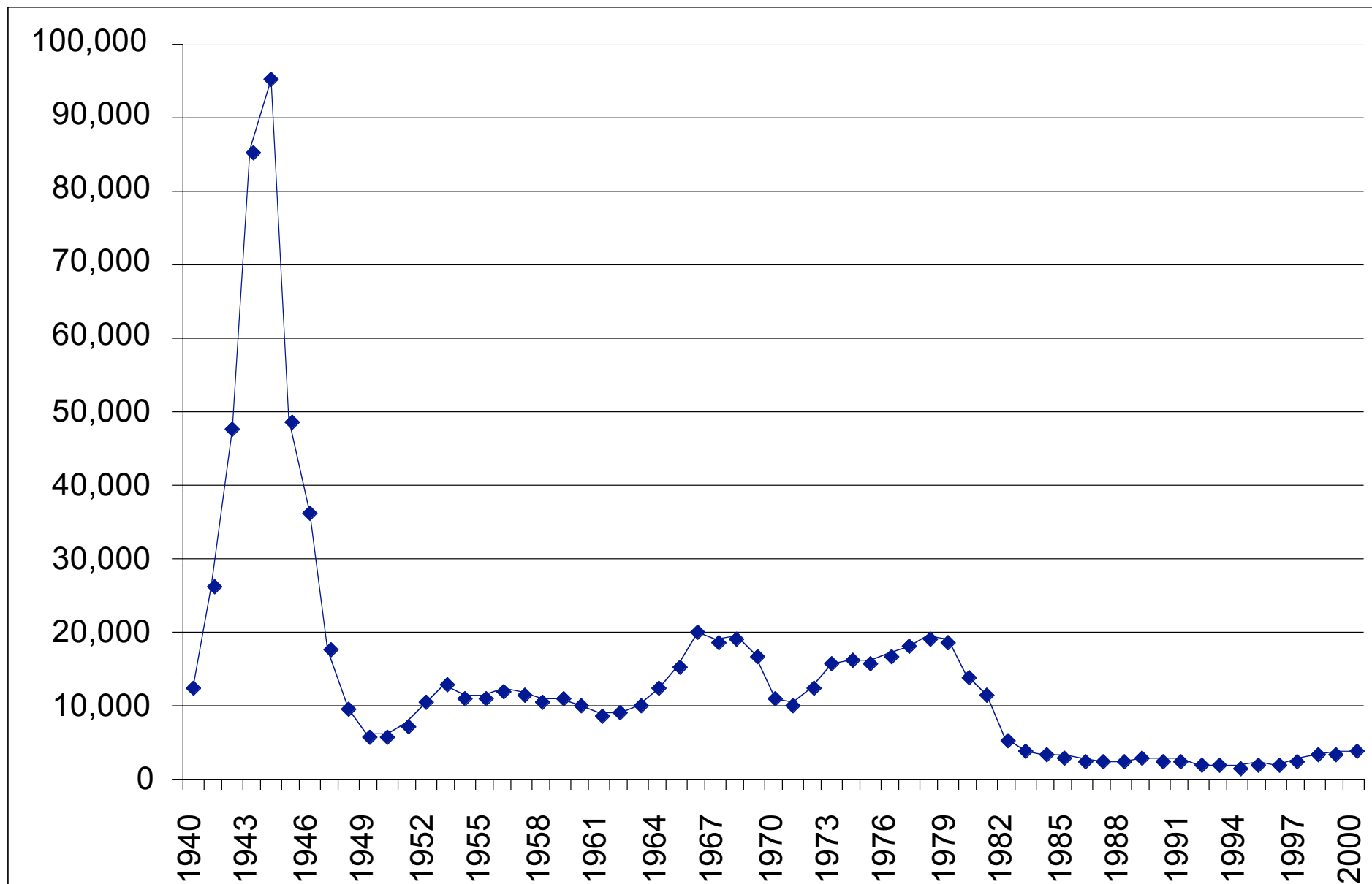
How America Lost and Regained its Lead in Flight Technology

- The airplane was invented in the U.S. but in little more than a decade Europe had moved to the forefront of the technology.
- Resulted from failure to invest in cutting edge R&D.
- U.S. played catch up until 1940s.
 - Required institutional investment in NACA/military labs.
 - Huge investments for military aircraft technology in latter 1930s-1940s.
 - Involved collaborative process of government, industry, and universities.
- “Science: The Endless Frontier,” report by Vannevar Bush (1945) signaled importance of Federal investment in technology for future success of U.S.

Top Fifteen Aircraft Manufacturers 1940-1945

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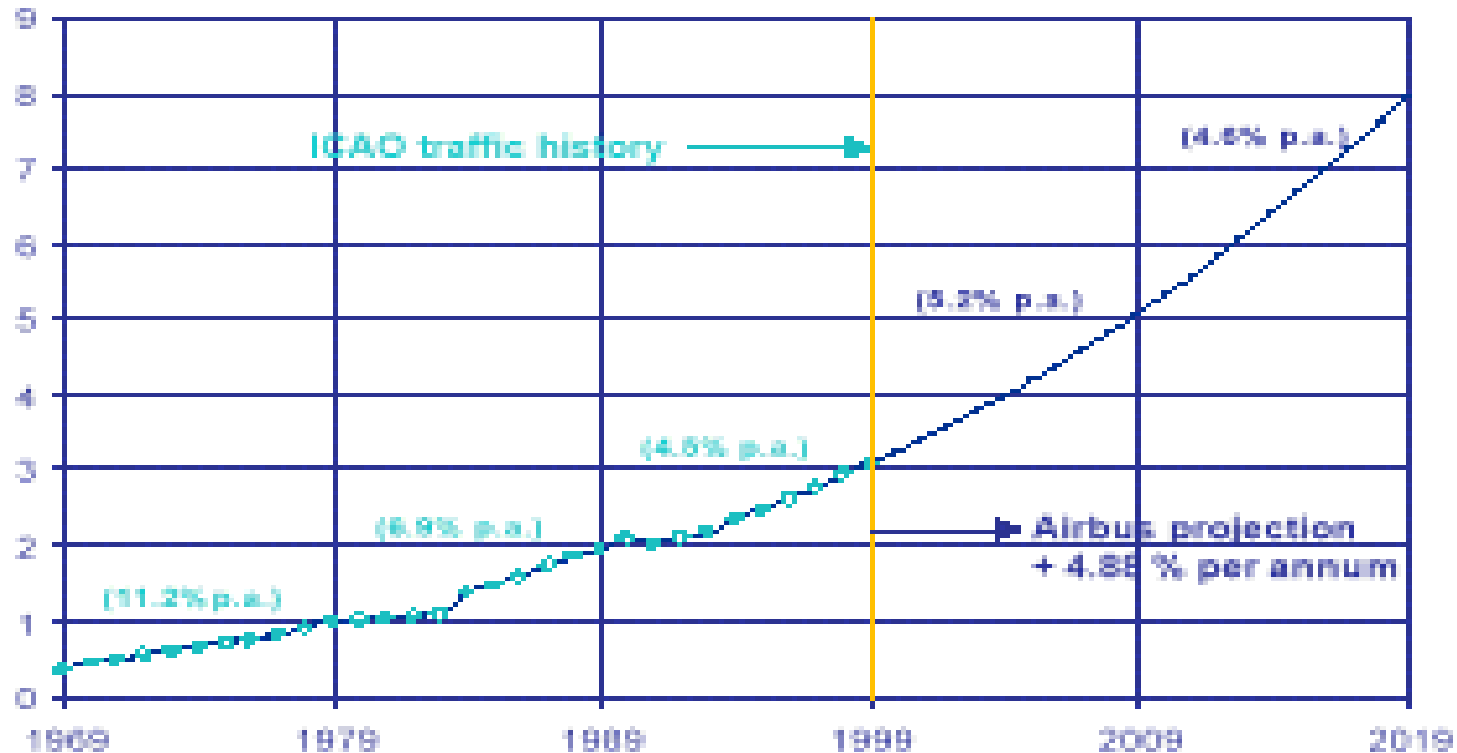
U.S. Aircraft Production, 1940-2000



Air Travel Projections 2000-2019

Air travel will continue to grow strongly

World annual traffic - trillion RPK



Airbus Projections for New Aircraft Sales

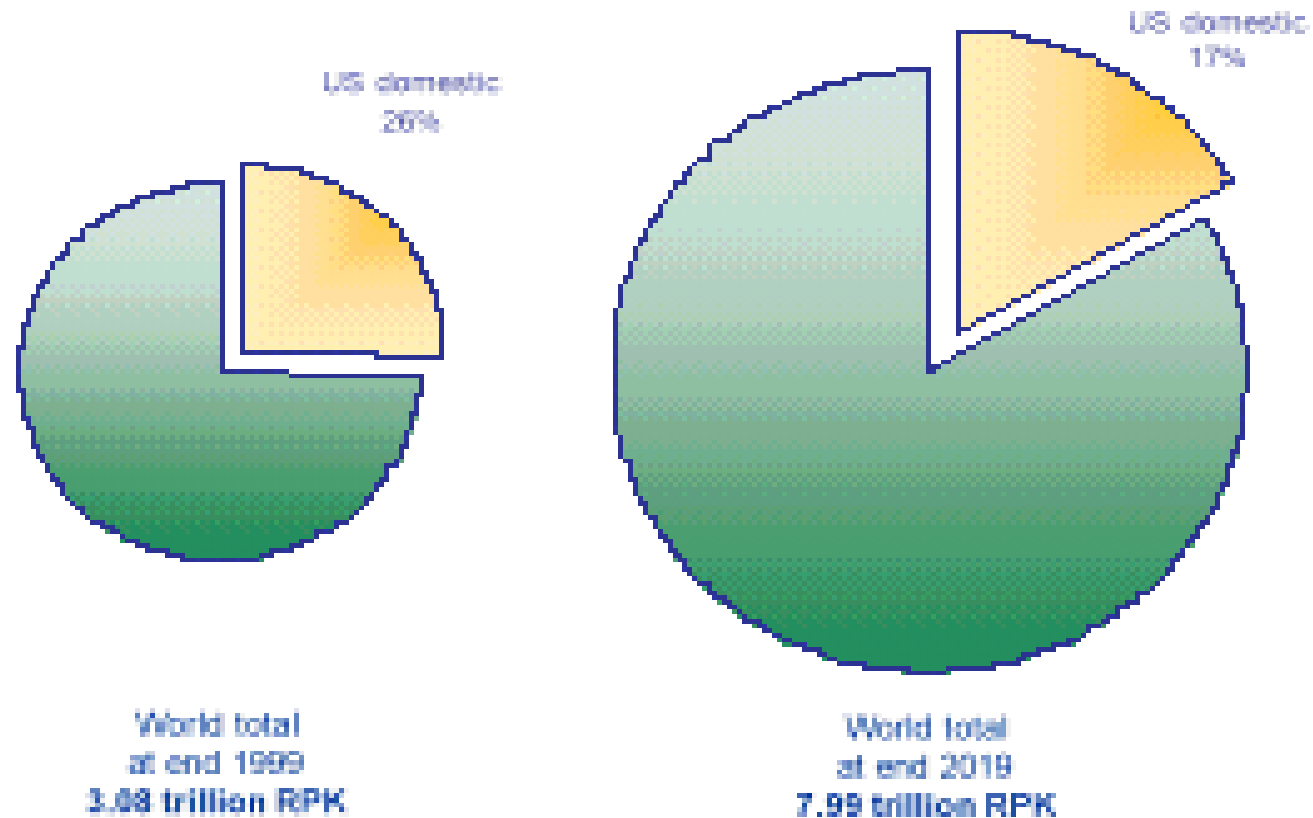
Nearly 15,400 new aircraft will be delivered ...

	2000 - 2009	2000 - 2019
70- & 85-seater regional jets	437*	692*
Mainline single-aisle types like the Airbus A318, A319, A320 and A321	4,330	7,670
200/250-seaters like the Airbus A300, A310 and smaller model A330s	1,127	3,046
Larger twin-aisles like the Airbus A330-300 and A340	1,083	2,118
Very large and economical aircraft like the Airbus A3XX	360	1,235
Total passenger aircraft	7,337	14,661
Freighters	271	703
Passenger + freighter aircraft	7,608	15,364

* many more of these aircraft will be needed by smaller airlines and current turboprop operators not covered by the GMF

U.S. Market Share to Decline

US domestic share of world traffic will decline



Spinoffs Often Associated with Aerospace Engineering

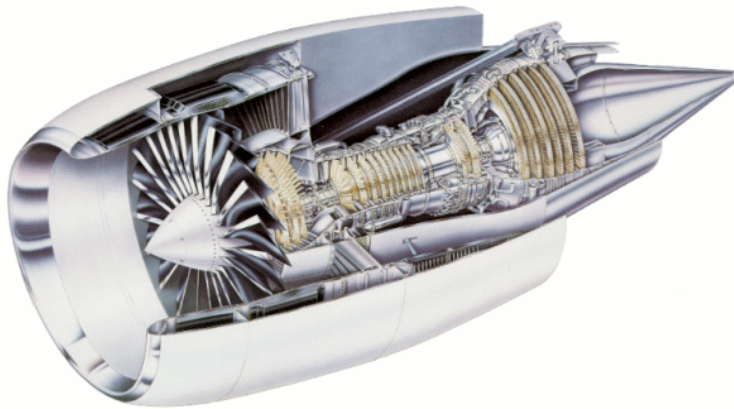


Teflon



Tang

The True Result of Aerospace R&D



Case Study: Federal R&D Used in C-17



- Supercritical wing technology, enhancing range, cruising speed, and fuel efficiency.
- Externally blown flap concept permitting slow, steep approaches with heavy payloads.
- Winglets for better cruise efficiency with a reduced wing span.
- Fly-by-wire technology used for a hydraulic control system.
- Advanced composite materials enabling significant weight savings.
- Flutter clearance tests of wing and winglet configuration.
- Fundamental research on deep-stall characteristics of T-tail aircraft, for development of C-17 angle-of-attack limiting system.

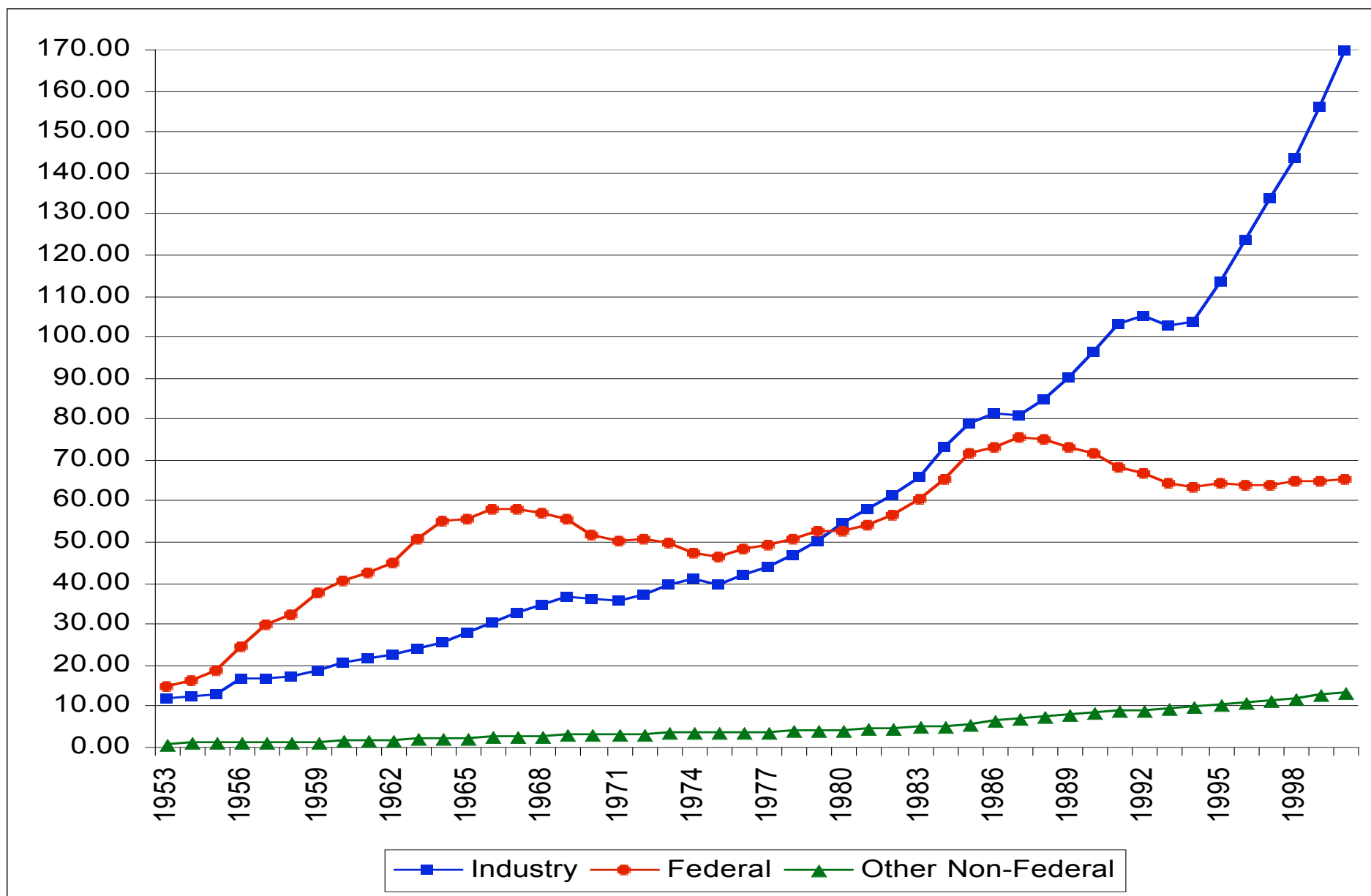
Overall R&D Investment Trends in the United States

- Since 1994, R&D investment in the United States has risen sharply, from \$169.2 billion to an estimated \$264.6 billion in 2000.
- Adjusted for inflation, this rise is \$176.2 to 247.5 billion in constant 1996 dollars.
- Annual real growth rate of 5.8 percent.
- Increase of \$71.3 billion 1996 dollars between 1994 and 2000 is the greatest single real increase for any six-year period since beginning to track this investment in 1953.

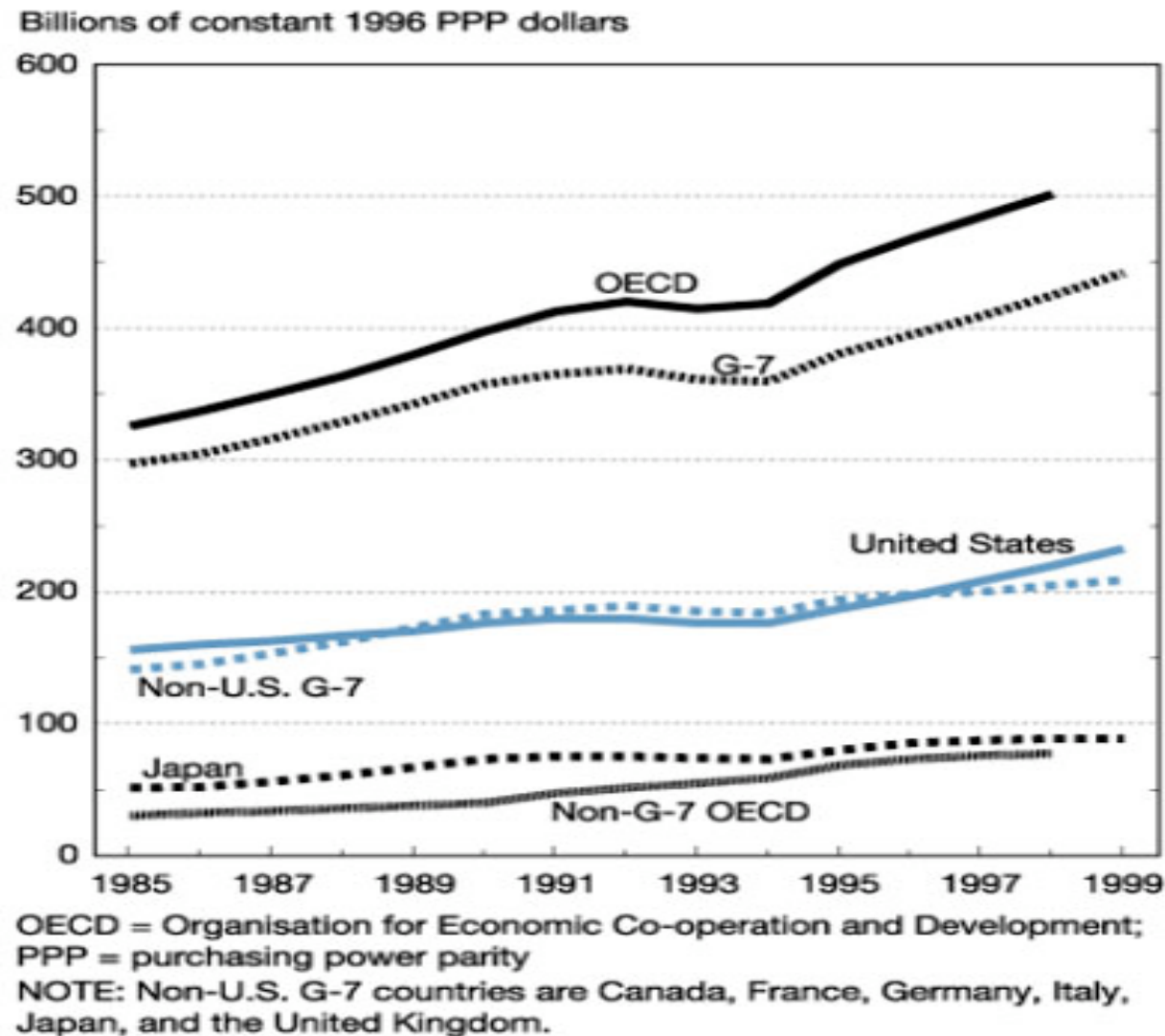
Recent Federal R&D Investment Trends

- In recent years, the Federal government has contributed ever smaller shares toward the nation's R&D funding.
- Federal government accounted for as much as 66.8 percent of all R&D investments in 1964.
- The Federal share of R&D funding first fell below 50 percent in 1979 and remained between 44 and 47 percent from 1980 to 1988.
- Since then, the Federal government's share has fallen even further, to 26.3 percent in 2000, the lowest in recorded history.

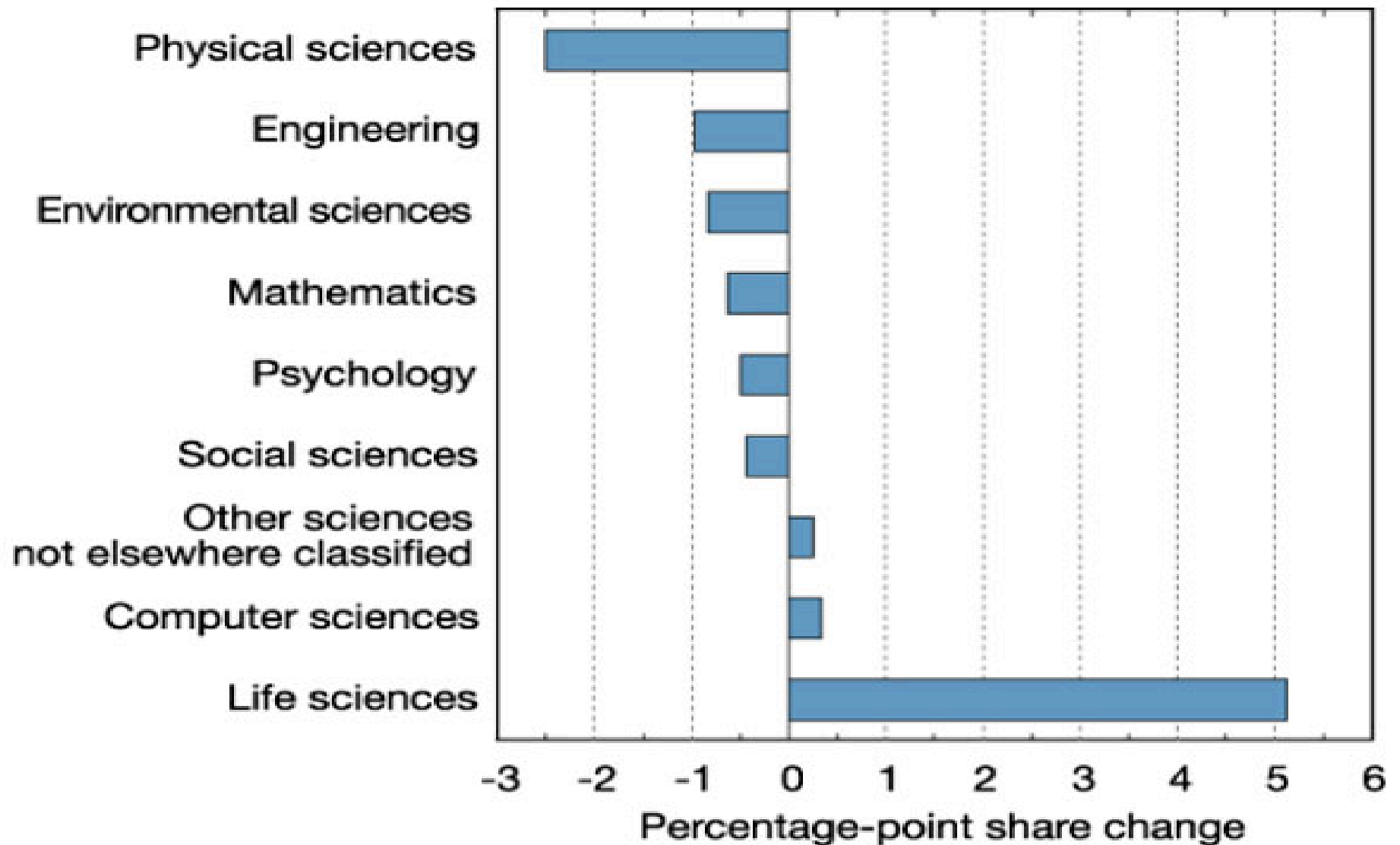
Total U.S. R&D Investment, 1953-2000



U.S., G-7, and OECD R&D Expenditures, 1985-1999



Changes in Federal R&D Support, 1990-1999



The Sorry State of Investment for Aerospace R&D

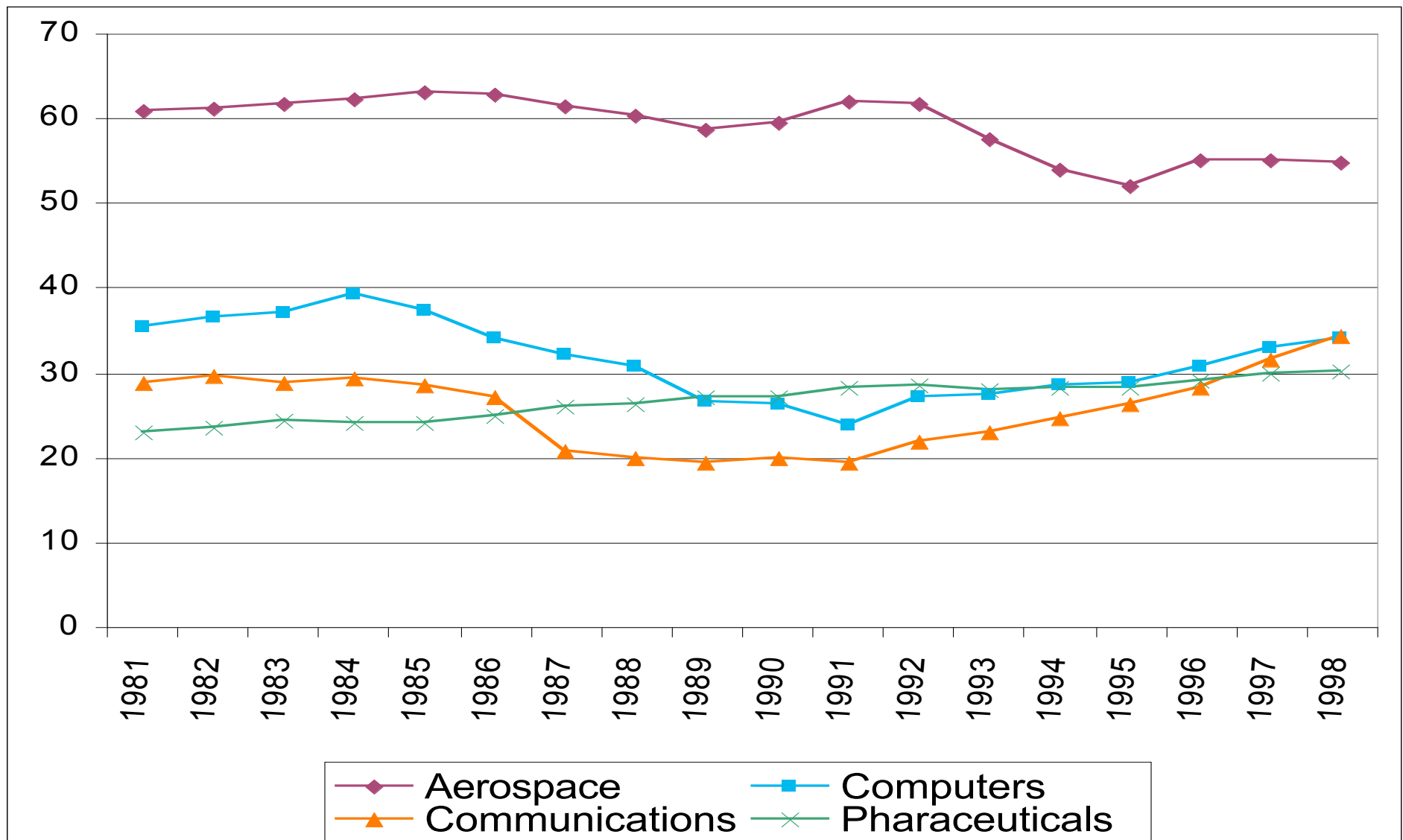
- U.S. is at a critical juncture regarding the long-term health of the aerospace industry in the United States.
- Knowledge is critical to maintaining U.S. competitive edge in aerospace technology.
- It is only possible to maintain U.S. leading edge by continuing to invest in a comprehensive R&D program.
- We are putting U.S. aerospace leadership at risk by our unwillingness to invest in R&D.

A Modest Proposal

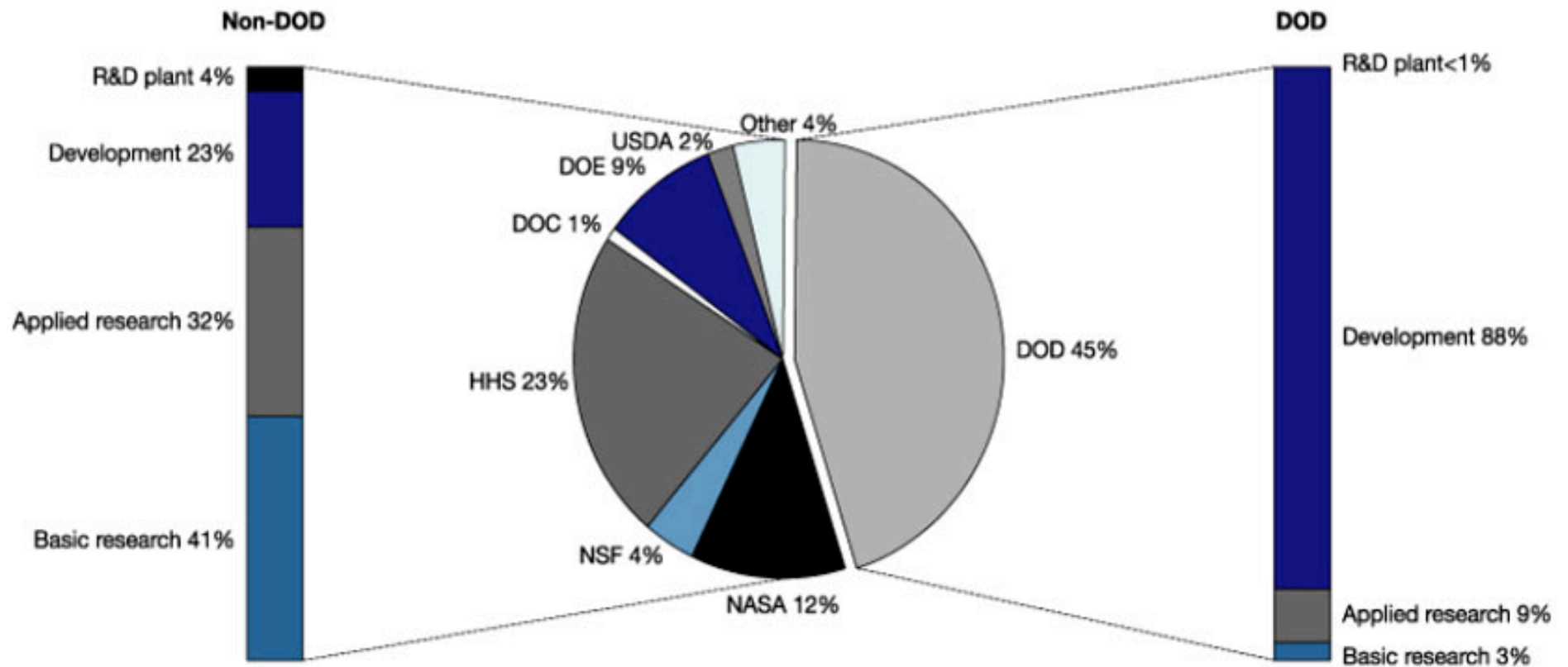
- How do we get out of the current aerospace doldrums?
- Concentrate on ensuring the technical superiority of American aerospace technology.
- There is a direct correlation between governmental R&D investment and excellence in technology.
- The American nation should double its Federal investment in aerospace R&D during the next decade in all sectors and through collaborative efforts.
- This investment is fully within bounds of U.S. capability.
- Helps to assure American economic, military, and technological competitiveness in the new century.
- Not to do so would be to turn our backs, as we did in the early 1900s on the legacy of the Wrights and their enormously significant invention.

Backup Slides

U.S. Global Share of High-Tech Industry, 1981-1998



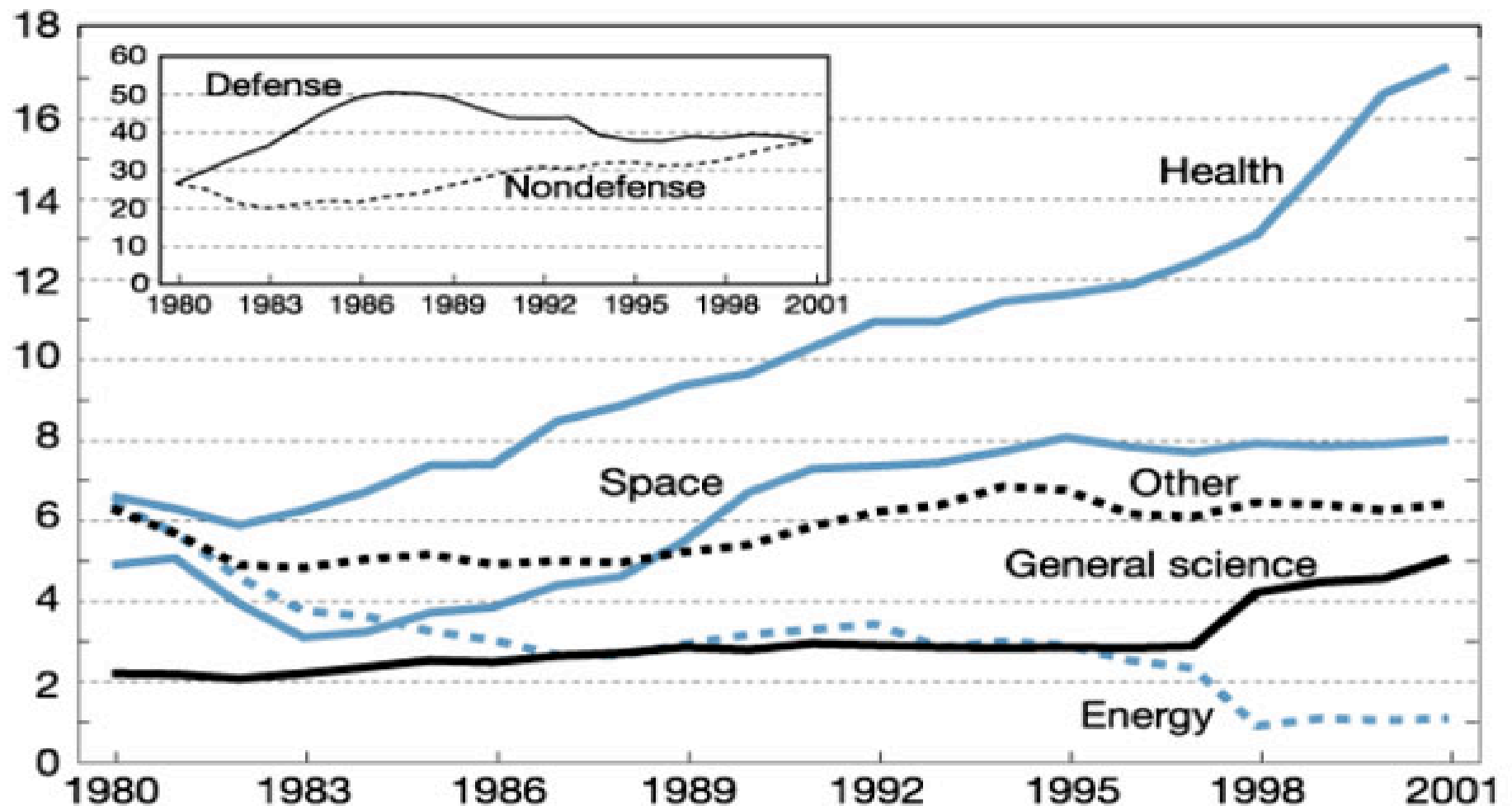
Federal Obligations for R&D, 2001



DOC = Department of Commerce; DOE = Department of Energy; DOD = Department of Defense; HHS = Department of Health and Human Services; NSF = National Science Foundation; NASA = National Aeronautics and Space Administration; USDA = U.S. Department of Agriculture

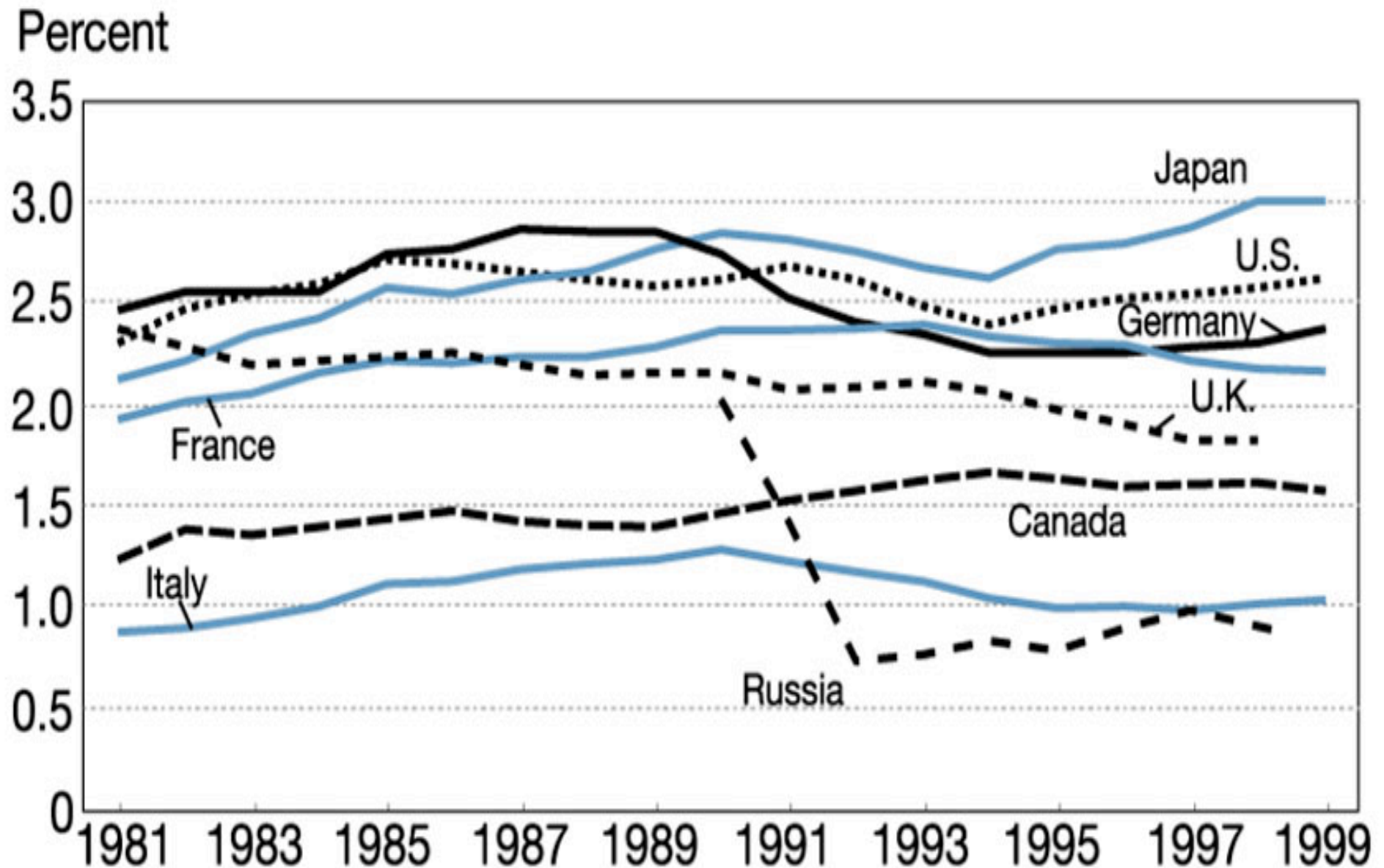
Federal R&D Funding, 1980-2001

Billions of constant 1996 dollars

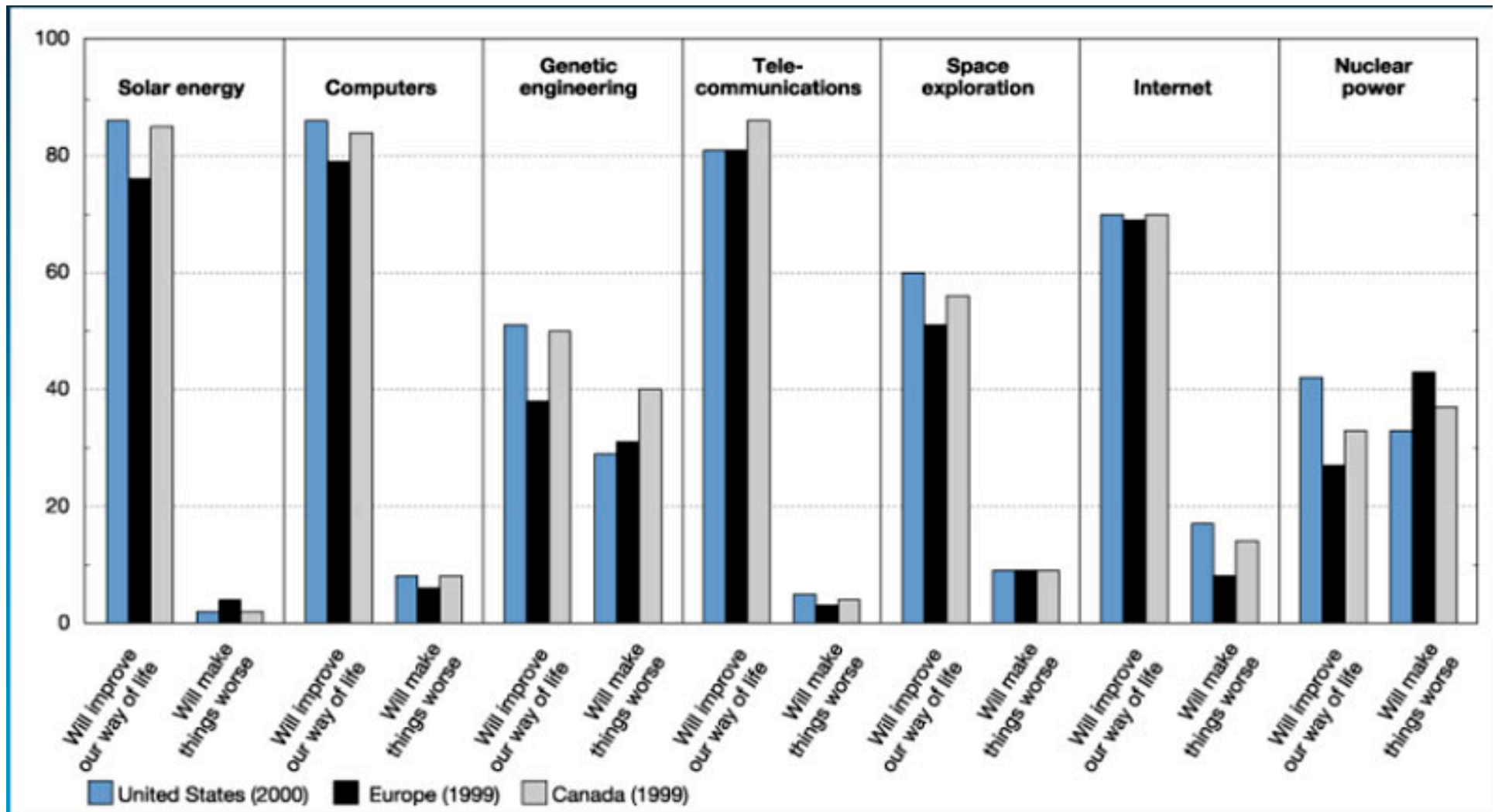


NOTE: The 1998 increase in general science and decrease in energy resulted from a reclassification.

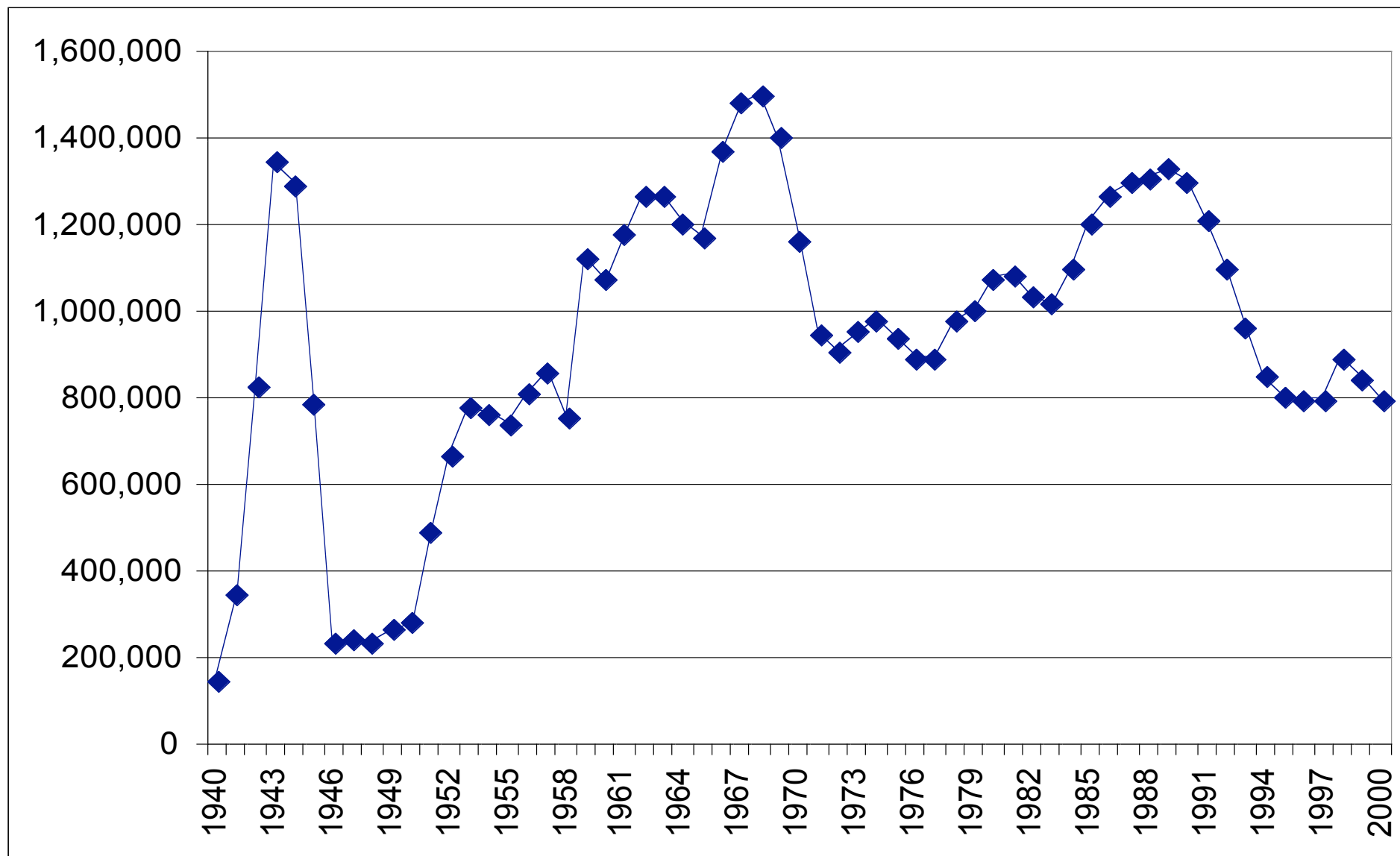
Total R&D as a Percentage of GDP



Public Attitudes toward Selected Technologies in the United States, Europe, and Canada, 2000



U.S. Aerospace Industry Workers 1940-2000



Federal Support to Specific Industries

- Federal R&D financing for specific industrial sectors has varied markedly across time and industries.
- Federal Government provided \$22.5 billion for industry R&D in 1999.
- Aerospace received 40.5 percent of Federal R&D funds provided to all industries in 1999.
- 63.2 percent of the aerospace industry's R&D dollars came from Federal sources; the remaining 36.8 percent came from those companies' own funds.
- In contrast, pharmaceuticals financed 100 percent of its R&D from company funds; machinery, 93.4 percent; computers, 83.3 percent; non-air transportation, 95.3 percent; information services, 96.8 percent.

Examples of Future R&D (1)

- Aircraft noise and engine emissions are among the greatest challenges that we face as an industry.
 - Ultra Efficient Engine Technology Program (UEET) may lead to lower total engine emissions, thus reducing production of greenhouse gasses in flight and reducing smog producing nitrogen oxides emissions around airports.
 - Breakthrough technologies to achieve significant reductions in aircraft noise and emissions will enable the industry to meet increased demand with minimal impact on noise and environmentally sensitive areas, while also lowering direct operating costs for the airlines by reducing fuel burn.

Examples of Future R&D (2)

- Synthetic Vision.
 - Enables pilot to fly in instrument conditions or darkness but look out of the cockpit onto a virtual skyscape like would be seen during a sunny day.
 - Virtual skyways superimposed on this skyscape would provide a visual flightpath that the pilot could follow.
 - Would contribute to more efficient airspace and airport utilization.
- Turbulence.
 - The leading cause of serious injury among cabin crews
 - Needs continued significant research efforts to detect air turbulence and provide sufficient warning for the crew.

Examples of Future R&D (3)

- Human Factors research.
 - Oriented toward human-machine interface on the flight deck, how humans behave in the maintenance and repair environment, decision-making, and crew interaction.
 - Two core questions:
 - How can we reduce human errors?
 - Since we cannot eliminate all human error, how can we design, produce, and maintain systems that will tolerate errors without resulting in an accident?
 - Critical to the government/industry partnership effort to improve safety in both general and commercial aviation.
 - Greater understanding in this arena will enable improved operational procedures and efficiency.

Examples of Future R&D (4)

- Non-Destructive Testing and Inspection.
 - accidents could have been avoided in the past if warning signs of existing physical problems had been seen.
 - Examples include engine disk failure and airframe structural failure.
 - Aspects under development include new hardware, as well as looking at the human dimension to address human factors such as boredom or fatigue that could lead a technician to miss a problem.
 - New efforts are underway looking for ways to inspect non-accessible areas where the very act of removal of wire bundles for inspection could cause damage and more problems that otherwise would not exist.

Five Key Reasons for the Aerospace Doldrums

- Inherent difficulties of the aerospace marketplace.
- Executives too often complacent in maintaining competitive technological edge.
- Lack—indeed a celebration of that lack—of coherent long-term industrial policy for the United States.
- Success of industrial policy by other nations aimed at securing greater market share for non-U.S. aerospace companies.
- Cyclic nature of aerospace industry, leading to boom and bust periods.